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(54) IMPROVEMENTS IN THERMOCHEMICAL COMBUSTIBLE GAS DETECTORS

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 USSR, a Russian corporate body, do hereby
 declare the invention, for which we pray
 that a patent may be granted to us, and the
 method by which it is to be performed, to be
 10 particularly described in and by the
 following statement:—

The present invention relates to devices
 for automatic detection of combustible
 gases and vapors in the atmosphere and,
 15 more particularly, to thermochemical
 combustible gas detectors.

Such devices are extensively used to
 indicate impermissibly high concentrations
 of combustible gases and vapors in mining,
 20 chemical, petrochemical, gas and other
 industries.

It is an object of the present invention to
 provide a thermochemical combustible gas
 detector having high operational stability
 25 within a broad range of combustible gas
 concentrations.

According to the present invention there
 is provided a thermochemical combustible
 gas detector comprising a resistor bridge in
 30 one of whose arms there is placed a ther-
 mistor sensitive to combustible gases, the
 adjacent arm including a thermistor which
 compensates the effects of other un-
 measured parameters and components of
 35 the atmosphere upon said sensitive ther-
 mistor, two remaining arms of the bridge
 being conventional resistors; there being
 connected to the supply diagonal of the
 bridge two conventional, series connected,
 40 auxiliary resistors whose resistances are
 greater than those of the thermistors, said
 auxiliary resistors forming, together with the
 sensitive and compensating thermistors, an
 additional resistor bridge;

45 a compensating voltage stabilizer through
 which the supply diagonal of said resistor

bridge is connected to a power source, said
 compensating voltage stabilizer having an
 amplifier-comparator link, whose input is
 connected to the measuring diagonal of the
 resistor bridge, and an auxiliary amplifier-
 comparator link whose input is connected
 either to the measuring diagonal of the
 additional resistor bridge, or to one of said
 auxiliary resistors, an adjusting link whose
 55 input is connected in parallel to the outputs
 of the amplifier-comparator links, its output
 being connected to the supply diagonal
 which is common for both bridges;

a signal indicator of impermissible
 concentrations of combustible gases in the
 atmosphere, whose input is connected to
 the output of any of the amplifier-
 comparator links of said stabilizer.

Said signal indicator can be connected to
 the output of the amplifier-comparator link.

The detector of the present invention is
 advantageous in that it has a high operating
 stability within a broad range of con-
 70 centrations of combustible gases and
 vapors.

Another advantage of the proposed
 detector resides in the simplicity of its
 circuitry.

Other objects and advantages of the
 present invention will become more ap-
 parent from the following detailed
 description of preferred embodiments
 thereof taken in conjunction with the ac-
 80 companying drawings, wherein:

Fig. 1 is a block diagram of a ther-
 mochemical combustible gas detector in
 accordance with the invention;

Fig. 2 is a block diagram of another
 embodiment of the detector in accordance
 85 with the invention;

Fig. 3 is a key diagram of said ther-
 mochemical combustible gas detector in
 accordance with the invention.

Referring now to the accompanying
 drawings, the proposed thermochemical
 combustible gas detector comprises a

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resistor bridge 1 (Fig. 1). Two adjacent arms of said resistor bridge 1 include thermistors 2 and 3, respectively. One of the latter, for example, the thermistor 2, is sensitive to the presence of combustible gases in the atmosphere, whereas the other thermistor 3 is intended to compensate the effects of unmeasured parameters and components of the atmosphere upon the sensitive thermistor 2. The two remaining adjacent arms of said bridge 1 include conventional resistors 4 and 5, respectively.

The sensitive thermistor 2 may be, for example, a coil, preferably, of platinum wire which at a certain temperatures acts as a catalyst for combustible gases and vapors. The compensating thermistor 3 is also a platinum wire coil. In order to avoid the catalytic action of the thermistor 3, the latter is coated with a catalytically inert compound. The same effect can be attained by making the thermistor 3 from thick wire in order to reduce its temperature to a point at which platinum is inert, or by using a greater winding pitch in said thermistor 3 than that of the sensitive thermistor 2.

In order to bring down the working temperature of the sensitive thermistor 2 and prolong its service life, said thermistor 2 can be coated with a thin film of a catalytically active compound which accounts for a lower oxidation temperature of combustible gases, as compared to platinum. In this case the compensating thermistor 3 needs no coating.

An alternative embodiment of said thermistors is platinum coils arranged either inside or on the surface of cylinders of a porous material, preferably, active aluminium oxide. The coils can also be arranged in spherical granules of the same porous material. In order to ensure catalytic activity of the sensitive thermistor, the latter is treated with a catalytic compound.

According to the invention, the supply diagonal of the resistor bridge 1 includes two conventional, series connected, auxiliary resistors 10 and 11. Together with the thermistors 2 and 3, said resistors 10 and 11 make up an additional bridge 12. The proposed thermochemical combustible gas detector further includes a semiconductor compensating voltage stabilizer 6 through which the supply diagonal of the resistor bridge 1 is connected to a power source 7. The stabilizer 6 is of a widely known type and normally includes an adjusting link 8 and an amplifier-comparator link 9. The input of the amplifier-comparator link 9 is connected to the measuring diagonal (points "a" and "b") of the bridge 1.

According to the invention, the compensating voltage stabilizer 6 is provided with an auxiliary amplifier-comparator link 13 whose input is connected either to the

measuring diagonal (points "a" and "c" of Fig. 1) of the additional bridge 12, or to one of the auxiliary resistors 10 and 11, for example, the resistor 11 (Fig. 2).

The auxiliary resistors 10 and 11 and the auxiliary amplifier-comparator link 13 provide for stable operation of the proposed thermochemical combustible gas detector within a wide range of combustible gas concentrations.

The adjusting link 8 can be built around a common-emitter or a common-collector transistor (the transistor may also be composite). The adjusting link 8 can also be built around transistors of different conductivities.

The function of the amplifier-comparator links 9 and 13 of the compensating voltage stabilizer 6 may be performed by different types of semiconductor d.c. amplifiers having at their inputs either tunnel diodes or reference voltage sources built around, for instance, semiconductor avalanche diodes with resistor voltage dividers.

The thermochemical detector of the present invention further includes a signal indicator 14 of combustible gas concentrations that are in excess of a maximum permissible concentration. According to the invention, in the case when the compensating stabilizer 6 includes the auxiliary amplifier-comparator link 13, the signal indicator 14 can be connected to the output of one of the amplifier-comparator links 9 and 13 of said stabilizer 6, for example, to the amplifier-comparator link 9.

This considerably simplifies the signal indicator 14, for in this case the latter can dispense with the threshold circuit of the prior art.

The function of said signal indicator 14 may be performed by a semiconductor d.c. amplifier at whose output there are a signal lamp and an audio oscillator whereto there is connected a loud-speaker. In order to produce an intermittent signal (which is the most effective), the amplifier may be replaced by a multivibrator. The signal indicator can be built into a miner's light whose lamp is used to send an alarm signal in the form of intermittent light. In order to reduce light losses, the power supply of the lamp should be switched with the aid of contacts of an electromagnetic relay whose winding is connected to the output of the multivibrator.

Fig. 3 is a key diagram of the proposed thermochemical combustible gas detector. In this detector, the adjusting link 8 of the stabilizer 6 is built around two transistors 15 and 16 of different conductivity types, the transistor 15 being the input transistor, whereas the transistor 16 is the output transistor, and an RC circuit composed of a

resistor 17 and a capacitor 18. Said RC circuit is connected to the power source 7. In addition, the adjusting link 8 includes a voltage divider built around resistors 19 and 20 and connected to the output of the link 8. The base of the transistor 15 is connected to the capacitor 18, whereas its emitter is connected to said voltage divider. There is negative feedback between the input and output of the adjusting link 8.

The amplifier-comparator links 9 and 13 are built around tunnel diodes 21 and 22, transformers 23 and 24, and d.c. amplifiers built around transistors 25 and 26, respectively. The tunnel diodes 21 and 22 of said links 9 and 13 are placed in series with the primary windings of the transformers 23 and 24 and make up oscillators; the secondary windings of these transformers are connected to the inputs of the transistors 25 and 26. The inputs of the amplifier-comparator links 9 and 13 are the circuits made up by the tunnel diodes 21 and 22 and the primary windings of the transformers 23 and 24; the outputs of said links 9 and 13 are the emitter-collector circuits of the transistors 25 and 26. Said outputs are connected to the input of the adjusting link 8, in parallel with the capacitor 18. For galvanic isolation of the output circuits of the amplifier-comparator link 9, which are connected to the input of the adjusting link 8 and the input of the signal indicator 14, a diode 27 is included in the output circuit of the link 9, which output circuit is connected to the input of the adjusting link 8.

The signal indicator 14 comprises a multivibrator built around transistors 28, 29 and 30, an electromagnetic relay 31 placed in the collector circuit of the transistor 30, and a signal lamp 32 whose circuit includes contacts 33 of said relay 31.

The proposed detector operates as follows.

As power supply is switched on and in the absence of combustible gases in the atmosphere, voltage is at once stabilized in the measuring diagonal of the bridge 1. This voltage is stabilized as follows. As power supply is turned on, the capacitor 18, arranged at the input of the adjusting link 8 of the stabilizer 6, starts being charged. As a result, voltage across the input and output of the adjusting link 8 and, consequently, in the measuring diagonal of the bridge, goes up. The capacitor 18 is charged until voltage in said diagonal reaches a level at which there is actuated the oscillator built around the tunnel diode 21 and the primary winding of the transformer 23, which are connected to the input of the amplifier-comparator link 9 connected, in turn, to the measuring diagonal of the bridge 1. As this takes place, the transistor 25 of the amplifier-comparator link 9 is driven into conduction, and its

emitter-collector circuit shunts the capacitor 18.

The latter is discharged, and voltage in the measuring diagonal of the bridge 1 decreases. The capacitor 18 discharges until voltage in said diagonal is brought down to a level at which the oscillator comprising around the tunnel diode 21 is no longer in action. After this, the capacitor 18 is charged again, which brings about an increase in the voltage in the measuring diagonal of the bridge 1, etc.

Thus, voltage of a strictly defined magnitude is set in the measuring diagonal of the bridge 1, to which diagonal there is connected the input of the amplifier-comparator link 9. This voltage has a constant component and a variable sawtooth component. Since the levels, to which the sawtooth voltage increases or decreases, are strictly defined by the oscillator being brought in and out of action, the effective voltage value is only slightly dependent upon the sawtooth voltage frequency. At the same time, said frequency is little dependent upon changes in the parameters of the adjusting link 8, due to the negative feedback between its input and output.

In the supply diagonal of the bridge 1, voltage is stabilized after the sensitive thermistor 2 and the compensating thermistor 3 have been warmed up. As stated above, voltage in the supply diagonal is proportional to that in the measuring diagonal, which proportion is defined by the ratio between the resistances of the thermistors 2 and 3 and those of the conventional resistors 4 and 5 placed in the arms of the bridge 1.

Combustible gas contained in the atmosphere is oxidized on the sensitive thermistor 2, which changes the latter's temperature and resistance and, consequently, changes the voltage in the supply diagonal of the bridge 1. As the concentration of the combustible gas goes up, this voltage may either increase or decrease, depending upon the polarity of the voltage being stabilized in the measuring diagonal of the bridge 1. It should be borne in mind, however, that according to the invention, the thermochemical detector must be adjusted so as to increase voltage in the supply diagonal prior to the appearance of the maximum permissible concentration of combustible gas in the atmosphere. Following the appearance of the maximum permissible concentration of combustible gas in the atmosphere, voltage in the measuring diagonal of the bridge 12 is stabilized, and its polarity must ensure a decrease of voltage in the supply diagonal with increasing concentration of combustible gas.

Under such conditions, when the concentration of combustible gas increases to reach a maximum permissible level, the amplifier-comparator link 9 of the stabilizer 6 is brought into play. The voltage in the measuring diagonal of the bridge 1 is stabilized, and the supply voltage of said bridge 1 increases. Simultaneously, there is an increase in the voltage in the measuring diagonal of the additional bridge 12. Besides, in the course of operation of the amplifier-comparator link 9, negative voltage is applied via the latter's transistor 25 to the base of the transistor 28 of the signal indicator 14, whereby said transistor is saturated and the multivibrator built around the transistors 28, 29 and 30 cannot operate. The relay 31 is not energized, and the signal lamp 32 is continuously lighted, which is proof of the fact that the signal indicator is in good condition.

As the concentration of combustible gas reaches a maximum permissible level, voltage in the measuring diagonal of the bridge 12 is brought to a level at which the auxiliary amplifier-comparator link 13 of the stabilizer 6 is brought into play. As this takes place, voltage in the measuring diagonal of the bridge 12 is stabilized as in the case of the measuring diagonal of the bridge 1; as the concentration of combustible gas continues to increase, the supply voltage of the bridge decreases. This, in turn, reduces the voltage in the measuring diagonal of the bridge 1, whereby the amplifier-comparator link 9 of the stabilizer 6 is brought out of action. The transistor 25 then removes negative voltage from the base of the transistor 28 of the signal indicator 14, and the multivibrator is brought into action. As this takes place, power is periodically supplied to the relay 31 whose contacts make the signal lamp 32 flicker. The latter indicates an impermissible high concentration of a combustible gas in the atmosphere.

It should be borne in mind that the rate of change in the voltage in the measuring diagonal of the bridge, as compared to the rate of change in the combustible gas concentration, is indicative of the sensitivity of the thermochemical combustible gas detector and depends upon the magnitude of the voltage being stabilized in the measuring diagonal of the bridge. The lesser this voltage, the higher the sensitivity. It is therefore essential that the sensitivity of the detector must ensure maximum possible operational stability of the detector within a broad range of combustible gas concentrations.

Such a stability is ensured if in the absence of combustible gases, the temperature of the sensitive thermistor 2 is kept at a minimum, but is sufficient to detect the

presence of combustible gases in the atmosphere. Then, as the combustible gas concentration reaches a maximum permissible level, the temperature of said thermistor 2 is increased to a level at which the concentration of combustible gas can be determined with high accuracy. Finally, with the appearance of explosive concentrations of combustible gas, the temperature of the sensitive thermistor is limited to a level at which no impermissible change in the characteristics of said sensitive thermistor can take place. In cases of high concentration, it is preferable that the temperature of the sensitive thermistor should be brought down to a lowest permissible level by adjusting the thermochemical detector's circuitry to the maximum sensitivity. It should also be pointed out that reduced temperatures of thermistors ensure a prolonged service life thereof.

Changes in the parameters and concentrations of unmeasured components of the atmosphere affect the sensitive thermistor 2 and account for additional errors in determining maximum permissible concentrations of combustible gases. Yet these changes equally affect the compensating thermistor 3, whereby said errors are substantially reduced.

When the auxiliary amplifier-comparator link 13 is connected to one of the resistors 10 and 11, for example, to the resistor 11 (Fig. 2), the amplifier-comparator link 9 operates as in the case when there is no combustible gas in the atmosphere reaches a maximum permissible level. An increase in the concentration of combustible gas leads to an increase in the voltage in the supply diagonal of the bridge 1 and, consequently, to an increase in the voltage across the resistor 11. As the concentration of the combustible gas reaches a maximum permissible level, the voltage across the resistor 11 reaches a level at which the auxiliary amplifier-comparator link 13 of the stabilizer 13 is brought into action. Voltage across the resistor 11 is stabilized, which equally applies to the voltage in the supply diagonal of the bridge 1; further increase in the concentration of combustible gas does not change the latter voltage. This makes it possible to limit the temperature increase rate of the thermistors 2 and 3 with impermissibly high concentrations of combustible gases and thus expand the working range of combustible gas concentrations. Since there is no increase in the voltage in the supply diagonal of the bridge 1 with an increase in the combustible gas concentration, an increase in the temperature and resistance of the sensitive thermistor 2 leads to a decrease in the voltage in the measuring diagonal of the bridge 1, whereby

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the amplifier-comparator link 9 of the stabilizer 6 is inoperative. As a result, a signal is applied to the input of signal indicator 14, and the latter gives an alarm signal.

Thus, the proposed combustible gas detector has a number of important advantages over the known types of detectors. These advantages include high operating stability of the detector within a broad range of combustible gas concentrations, longer service life of the sensitive and compensating thermistors, and a relatively simple circuitry of the detector. All the foregoing factors account for high reliability, simple adjustment and maintenance, and small size and weight of the proposed thermochemical combustible gas detector.

20 WHAT WE CLAIM IS:—

1. A thermochemical combustible gas detector comprising a resistor bridge in one of whose arms there is placed a thermistor sensitive to combustible gases, the adjacent arm including a thermistor which compensates the effects of other unmeasured parameters and components of the atmosphere upon said sensitive thermistor, two remaining arms of the bridge being conventional resistors; there being connected to the supply diagonal of the bridge two conventional series connected, auxiliary resistors whose resistances are

greater than those of the thermistors, said auxiliary resistors forming, together with the sensitive and compensating thermistors, an additional resistor bridge;

a compensating voltage stabilizer through which the supply diagonal of said resistor bridge is connected to a power source, said compensating voltage stabilizer having an amplifier-comparator link, whose input is connected to the measuring diagonal of the resistor bridge, and an auxiliary amplifier-comparator link whose input is connected either to the measuring diagonal of the additional resistor bridge, or to one of said auxiliary resistors, an adjusting link whose input is connected in parallel to the outputs of the amplifier-comparator links, its output being connected to the supply diagonal which is common for both bridges;

a signal indicator of impermissible concentrations of combustible gases in the atmosphere, whose input is connected to the output of any of the amplifier-comparator links of said stabilizer.

2. A thermochemical combustible gas detector, substantially as hereinbefore described with reference to the accompanying drawings.

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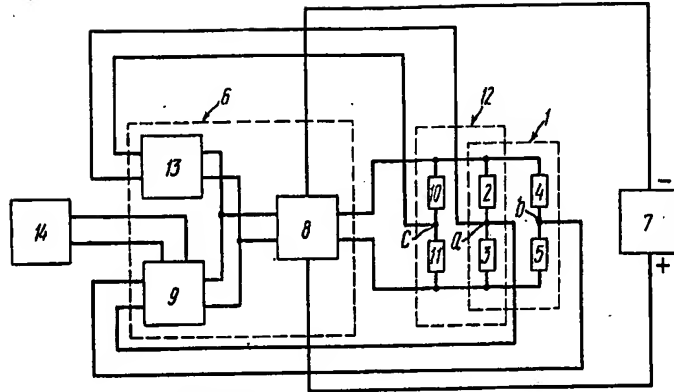


FIG. 1

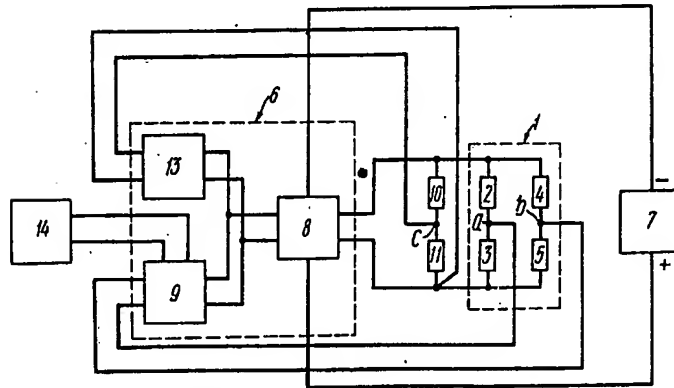


FIG. 2

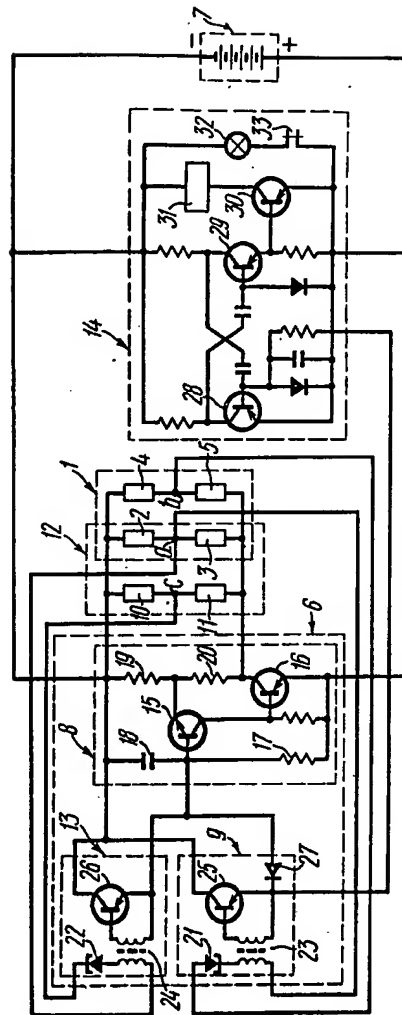


FIG. 3